# APPENDIX B

## RULING GRADE-EXAMPLE PROBLEM

**B-1**. This example of determining a trail ruling grade for a new railroad line follows the mat presented in paragraphs 3-4, 3-5, and 3-6.

**B-2**. A railroad line is to be built from terminal serving the new training area at Example to the nearest commercial railroad, a 15 miles away. The most critical traffic, heaviest loads, will be M-1 tanks on flat (Each car is 70 feet long and has a maximum loaded weight of 187 tons riding on 6 axles). The installation has one 1,500 HP, 100 ton locomotive

**B-3**. To handle movements during larger training exercises and mobilization, the installation w to use an engine from the connecting rail which will be capable of hauling 25 loaded over the line at 15 MPH average speed. The connecting railroad expects to have a 3,000 170 ton (340,000 pound) locomotive available when needed. (Tractive effort curves are not available for either locomotive. For simplicity, let locomotive length equal car length.)

**B-4.** The designer must now determine the n mum effective gradient (and grade length) on new line to accommodate these train movements:

*a. For the commerical locomotive.*

(1) Traction Limit = 340,000 / 4 = 85,000

(2) Tractive Effort at 15 MPH = 300 x 3,000/15 = 60,000 lbs.

Engine power governs usable tractive effort.

*b. Ruling Grade.*

TE = 60,000 lbs

$W_{Eng}$ = 170 tons

$W_{Car}$ = 187 tons

Ncar = 25

G = 60,000 / 20(170 + 25 x 187) - 0.15

= 0.47*%*

Grade length = 26 (engine and cars) x 70=1820 Feet (or longer)

Thus, grades of 1820 feet or longer would has be limited to an effective gradient of 0.47*%.*

**B-5**. From a brief review of contour maps of the area through which the route would run, the designer believes the route may require grades much steeper than 0.47% to keep construction costs at an acceptable level.

**B-6**. One way to accommodate the desire to I single trains of 25 loaded flats at an average speed of 15 MPH and allow for a steeper ruling grade is to use the installation's engine and commercial engine together and drop the travel speed up the ruling grade to 10 MHP, which should further increase the tractive effort available. To offset the out loss in speed up the ruling grade, other portions of the route might be constructed to accommodate higher speeds-perhaps 25 to 30 MPH. A check of this possibility shows the following:

*a. For the commercial locomotive.*

(1) Traction limit = 340,000 / 4 = 85,000 lbs.

(2) Tractive Effort at 10 MPH = 300 x 3,000 /10 = 90,000 lbs.

Traction limit governs usable tractive effort.

*b. For the installation's locomotive.*

(3) Traction limit = 200,000 / 4 = 50,000 lbs.

(4) Tractive Effort at 10 MPH = 300 x 1,500 /10 = 45,000 lbs.

Engine power governs usable tractive effort.

*c. Ruling Grade.*

TE = 85,000 + 45,000 = 130,000 lbs.

$W_{Eng}$ = 170 + 100 = 270 tons

$W_{car}$ = 187 tons

$N_{car}$ = 25

RR = 3 lbs/ton

G = 130,000 / 20(270 + 25 x 187) - 0.15

= 1.16%

Grade length = 27 x 70 = 1890 Feet (or longer)

Thus, if this revised arrangement is acceptable, grades of 1890 feet or longer could have an effective gradient as high as 1.16%. Table B-1 shows the curve compensation for curves on this grade.

*Table B-1. Curve Compensation for a 1.16% Grade.*

| Degree of | Uncompensated Grade | | Compensated Grade | |
|---|---|---|---|---|
| Curve | Actual | Effective | Actual | Effective |
| 1 | 1.16 | 1.20 | 1.12 | 1.16 |
| 2 | 1.16 | 1.24 | 1.08 | 1.16 |
| 3 | 1.16 | 1.28 | 1.04 | 1.16 |
| 4 | 1.16 | 1.32 | 1.00 | 1.16 |
| 5 | 1.16 | 1.36 | 0.96 | 1.16 |
| 6 | 1.16 | 1.40 | 0.92 | 1.16 |

*d.* From the table, if a 5 degree curve was located within the ruling grade, the constructed (actual) gradient through that curve must be limited to 0.96*%* to keep the effective gradient within 1.16*%.*